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Mission to the Area Affected by the Earthquakes in the Pianura Emiliana-Padana of May-June 2012

Brief Note

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The present Note summarizes the results of a technical mission by the JRC to the area affected by the recent earthquake and aftershocks which struck Northern Italy in the last two weeks[1]. The technical mission focused mainly on a preliminary evaluation of the performance of **precast industrial buildings**.

It is estimated that **75% of these buildings suffered damage or collapsed**. Slight damage to a motor-way bridge structure and liquefaction in the town of San Carlo were also observed. A mission detailed report elaborated with photos and maps will follow shortly.

Due to the limited duration of the mission and the difficulties in getting close to and around the damaged buildings, the quantitative evaluation as well as the technical assessments should be considered provisional.

Areas/Places Visited:

- Headquarters of the Regional Civil Protection in Bologna.
- San Felice sul Panaro, Sant'Agostino, San Carlo, Finale Emilia, Mirandola, Mendolla, Concordia sulla Secchia, Novi di Modena, Cavezzo.

Seismicity

- Area affected by the earthquake: approximately 60 km (east-west) x 30 km (north-south) (see Figure 1).
- Maximum Peak Ground Acceleration (PGA) in the range of 0.30g, concentrically decaying very rapidly around the epicenter (USGS gives accelerations in the order of 0.08g at 25 km from the epicenter for the earthquake of 29 May2012).

Standards

- Area considered non-seismic before 2003 (plus grace period and permission filing). Current seismic zoning corresponds to 0.15g PGA for 475 years return period (yrp).
- No detailed provisions provided by the Italian Norms for beam- to-column connections of precast buildings designed for seismic loading.

Inventory

- Most precast buildings were designed and constructed before 2003 (plus grace period and permission filing): designed for gravity loads, beam-to-column joints with no connections capable of transferring horizontal loads and insufficient sitting, isolated column foundations.
- Few buildings designed during the last 5-7 years (i.e., with seismic provisions), the majority found in Mirandola, Concordia sulla Secchia and Novi di Modena.

Damage
(see typical pictures in Figures 2-5)

[1] This Brief Note was first edited in June 2012

- For precast industrial buildings designed with non-seismic provisions in the affected area: 75% presented damage and detachment of the exterior cladding, with 25% presenting partial or total collapse of the roof and girders (due to un-sitting of the main girder). *Note: values are estimated from the observations*.

- The collapse of cladding was due to insufficient capacity (strength or ductility) of the connections.

- For precast industrial buildings designed with seismic provisions in the affected area: no damage of the main structure or cladding, with the exception of one building that presented partial collapse.

- One case of a precast building with steel ties in the transverse direction showing no damage (the original purpose of the steel tie is unknown).

- Failure of steel racks used for storage, especially very tall ones (in excess of 10 m), which, sometimes, were the cause of damage to the enveloping building.

Response to the Disaster

- Tagging of precast buildings for usability will be made by civil engineers upon being called by building owners. The procedure for assessment is being discussed by the competent authorities.

- The question of how usability is assessed remains open: vulnerability vs. damage based. The assessment method will be crucial for the definition of the future usability of precast buildings. Even if undamaged, precast buildings designed with no seismic provisions are highly vulnerable and may experience high levels of damage in the event of future aftershocks similar to the main event.

- There is a high potential of indirect economical losses due to the interruption of the economic activities due to the precast industrial buildings. There is a risk of relocation of activities to areas not affected by the earthquake.

Recommendations (provisional)

- Develop guidelines for retrofitting precast buildings designed to non-seismic provisions.

- Develop guidelines for the prescriptive design of connections of precast buildings in seismic regions.

- Improve the design of the connections of panels (through performance requirements) in seismic regions and assess their contribution (if any) to structure global stiffness.

- Develop guidelines for the design of steel racks in seismic regions.

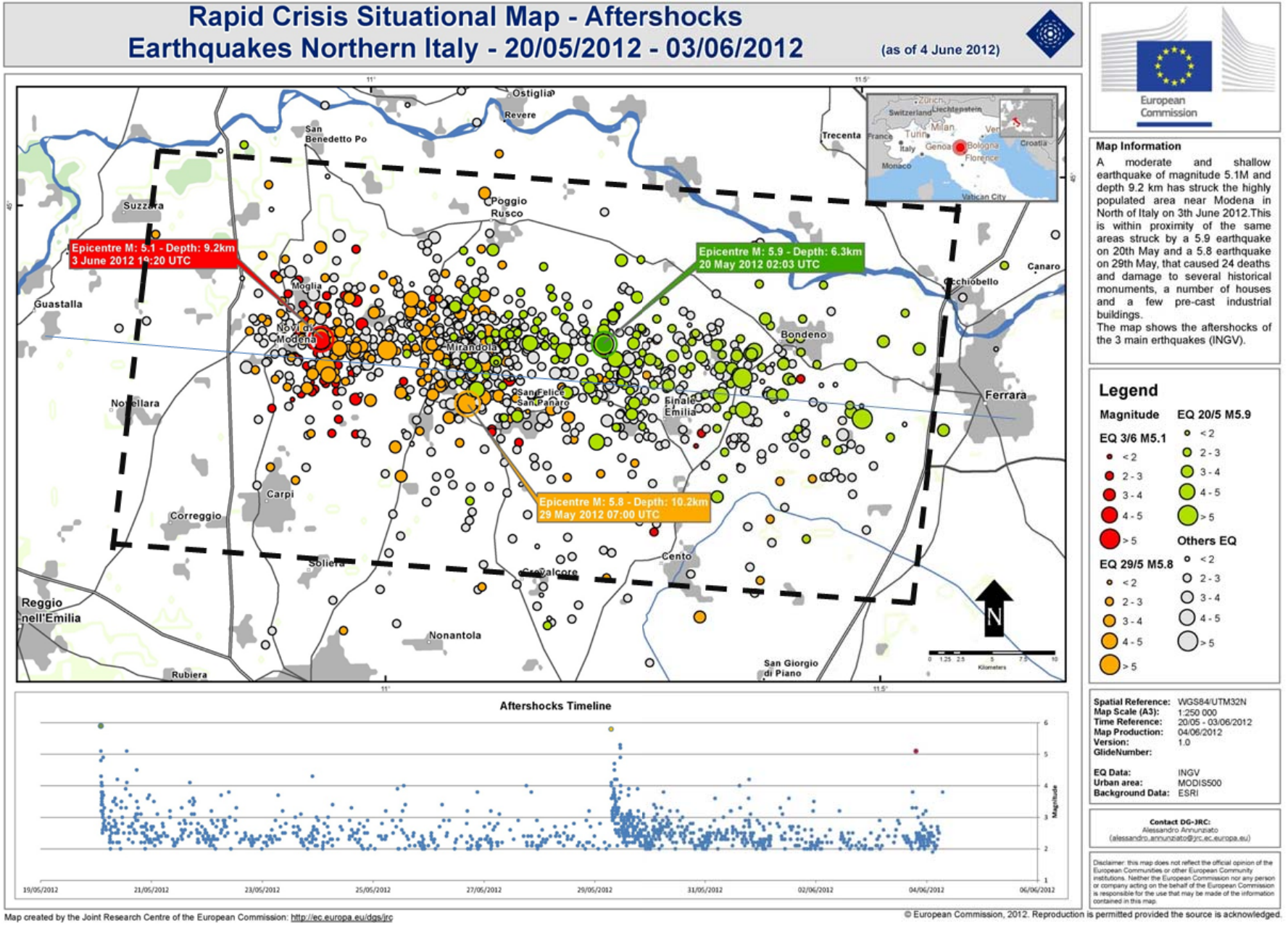

Figure 1 - Rapid Crisis Situational Map – Aftershocks Earthquakes Northern Italy - 20/05/2012 - 03/06/2012
(Source DG-JRC CRITECH Action: A. Annunziato)

Figure 2: Seating of precast beams in the columns' forks

Figure 3: Loss of beam seating from central column and collapse.

Figure 4: (a) Out-of-plane unseating of the girder. (b) Shear rupture of a column fork

Figure 5: Modern precast concrete building which exhibited good performance during the earthquake events of May 2012

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Abstract

A field mission was conducted in the region affected by the May-June 2012 earthquakes in the Pianura Padana-Emiliana in Northern Italy. The field mission was organized to study the effects of the earthquakes mainly for what concerns prefabricated reinforced concrete industrial buildings, recognizing the important effect that the Pianura Padana-Emiliana earthquakes had on this type of structures, which caused the majority of human casualties, with no precedent in other earthquakes in Italy and Europe. Most of these buildings, designed for gravity loads only, were highly vulnerable, as they were designed prior to enforcement of the latest seismic zoning dating back to 2003 that changed the affected area from non-seismic to a low to medium seismicity level. Due to the limited duration of the mission and the difficulties in getting close to and around the damaged buildings, the quantitative evaluation as well as the technical assessments should be considered provisional. Slight damage to a motor-way bridge structure, to a new pilotis building and liquefaction in the town of San Carlo were also observed. Recommendations for the reconstruction phase and for the reduction of the vulnerability of similar existing prefabricated industrial buildings in seismic regions are proposed at the end of the report.

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